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Title: OPTIMUM BIASING SYSTEM FOR ELECTRONIC DEVICES ;

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ABSTRACT:

A biasing system is described which provides essentially total immunity against slow background fluctuations, coupled with excellent detection sensitivity for fast signals. Its principle is a control loop, based on an operational amplifier 15, which senses the output voltage of the device 10 and adjusts the bias applied to it via a network 16, so that it remains at a constant level, determined by the reference bias 14. The bias generating network 16 also acts as dynamic load and thus high stage gain can be achieved, yielding excellent sensitivity and S/N ratio. The control is made effective at low frequencies only, by including a low pass filter 13. Thus, high frequency signals are unaffected. The principle is illustrated with a photodiode circuit which provides immunity against extreme variations in ambient lighting conditions.

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G1A
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# (54) Optimum biasing system for electronic devices

(57) A biasing system is described which provides essentially total immunity against slow background fluctuations, coupled with excellent detection sensitivity for fast signals. Its principle is a control loop, based on an operational amplifier 15, which senses the output voltage of the device 10 and adjusts the bias applied to it via a network 16, so that it remains at a constant level, determined by the reference bias 14. The bias generating network 16 also acts as dynamic load and thus high stage gain can be achieved, yielding excellent sensitivity and S/N ratio. The control is made effective at low frequencies only, by including a low pass filter 13. Thus, high frequency signals are unaffected. The principle is illustrated with a photodiode circuit which provides immunity against extreme variations in ambient lighting conditions.

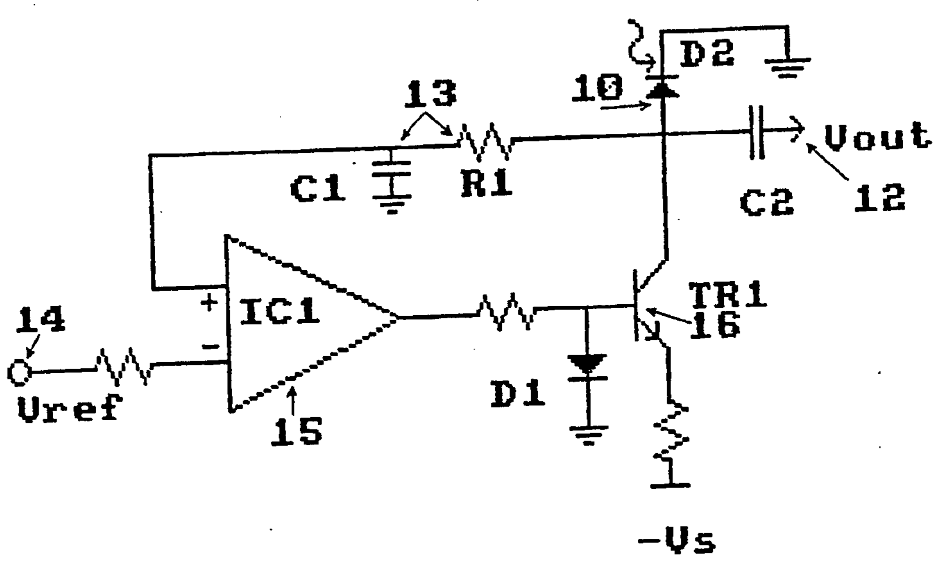


FIGURE 2

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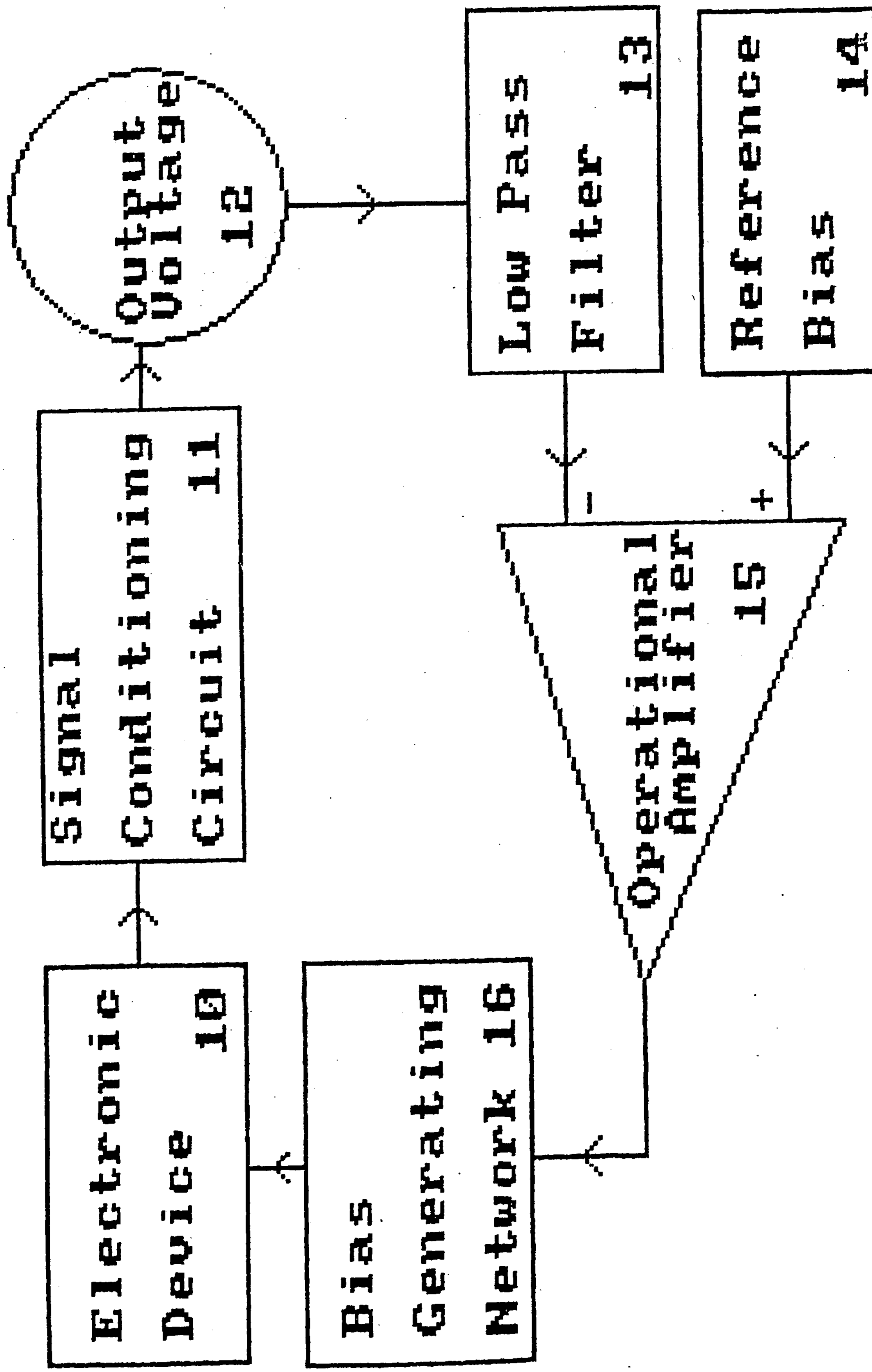


FIGURE 1

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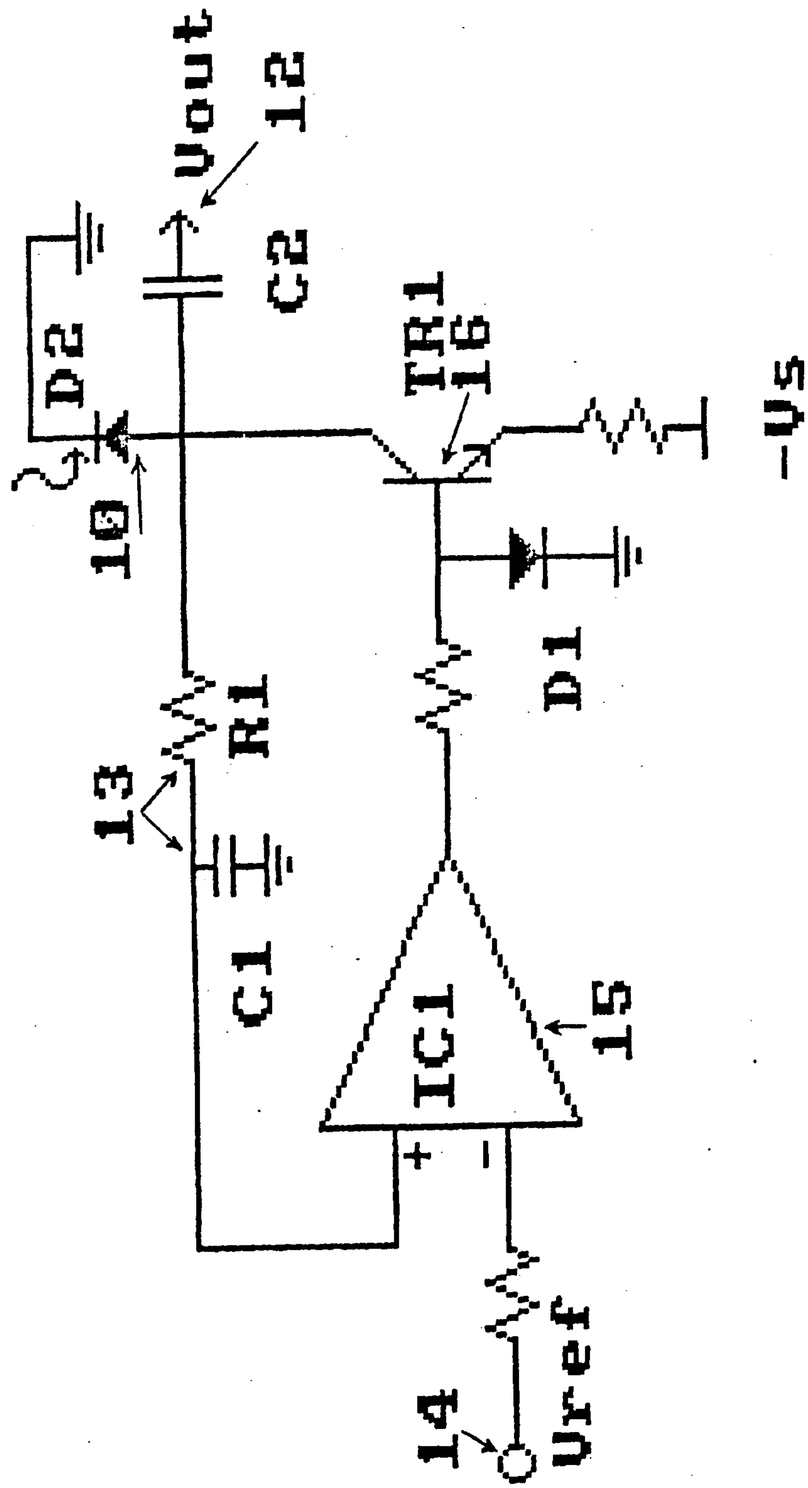


FIGURE 2

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# OPTIMUM BIASING SYSTEM FOR ELECTRONIC DEVICES

This invention relates to an improved technique for controlling the operating point of electronic devices, so that their output is made insensitive to SLOWLY varying background fluctuations, while excellent sensitivity can be achieved to FAST signals.

Various techniques are in existence for biasing electronic devices e.g. transistors, photodetectors etc., so that their often strong dependence on background parameters, such as temperature and light, is minimised. In general, these techniques suffer from several disadvantages viz. i) they require making a compromise between operating point stability and signal sensitivity, since the circuit configurations used to reduce their dependence on background fluctuations also reduce the device sensitivity against the signals themselves. ii) they yield limited dynamic range circuits and introduce non-linearities in the system response even in regions well away from the saturation points. This makes circuit design problematic, since it necessitates either a priori knowledge of the dynamic range limits or the incorporation of some form of external adjustment, which is usually undesirable, due to its subjective nature and the incumbent loss of equipment simplicity. iii) some require considerable circuit complexity e.g. second or third order temperature compensation circuits.

According to the present invention, the system consists of an electronic device to be stabilised and a control system which maintains the operating point of the device to a constant, pre-determined value.

A specific embodiment of the invention will now be described by way of example for the stabilisation of a photodetector against background light fluctuations. It should, however, be emphasised that the applicability of the technique is very general and encompasses the stabilisation of essentially ANY device against external influences. Examples are : the stabilisation of transistors, diodes and other semiconductors against temperature fluctuations and of transducers against background fluctuations of the parameter that they are supposed to measure (e.g. magnetic sensor stabilised against the earth's magnetic field) etc.

The core of a basic, general system is described with reference to the block diagram shown in Figure 1.
The Electronic Device 10 is followed by an (optional) Signal Conditioning Circuit 11, which produces a suitable Output Voltage 12 proportional to the parameter of interest (e.g. light level). This Output Voltage is fed through a Low Pass Filter 13 to one input of an Operational Amplifier 15 which forms the bias control loop.

This input of the Operational Amplifier must obviously be chosen with due regard to signal inversions around the various intervening circuits so that it results in overall NEGATIVE feedback, otherwise the system will be unstable. Some form of frequency compensation (not shown in this diagram) may be necessary, in order to achieve stability. The other input of the Operational Amplifier is connected to the Reference Bias block 14 which sets up a voltage corresponding to the required operating point conditions. The Operational Amplifier is followed by the Bias Generating Network 16, which produces the correct biasing conditions for the Device. This network 16 also serves as a high impedance dynamic load for the Device, so that very high values of voltage gain can be obtained which result in excellent sensitivity and improved Signal/Noise performance since high gain is placed EARLY in the amplification chain of the system. This point will become clearer in the photodiode circuit outlined below. An important component of the system is the Low Pass Filter. This allows essentially complete insensitivity against SLOW variations of the parameter under measurement (assuming that an Operational Amplifier of sufficiently high gain has been used), due to the effect of the negative feedback which forces the output voltage to be equal to the reference bias. This is because the Low Pass Filter shapes the frequency response of the loop gain so that it is very high at low frequencies but drops to zero at high frequencies. Thus, the useful signal is not affected by the negative feedback, if care is taken to ensure that the low frequency limit (3db point) of the passband is well ABOVE the corner frequency of the Low Pass Filter (by say a decade). and full signal sensitivity is maintained.

A specific example to illustrate the application of the above general principles to a photodiode circuit is shown in Figure 2. In this case the Electronic Device 10 is the photodiode D2. There is no need for Signal Conditioning Circuit 11, since the photodiode produces a voltage proportional to the light level which can be fed directly to the Low Pass Filter 13 formed by the resistor-capacitor combination C1,R1. The Reference Bias 14 is simply a dc voltage level generated externally (its generation is trivial and is not shown in this sketchy circuit diagram). IC1 is the Operational Amplifier 15 with the correct input polarity for this particular application (TR1 causes a signal inversion).

The transistor TR1 forms a voltage controlled current source and is, therefore, the Bias Generating Network 16. This current source has a very high dynamic impedance (of the order of mega ohms) and therefore a very high voltage gain can be achieved at the output 12. Care must be taken not to lower this high impedance by loading the collector of TR1. Thus R1 must be very high, as must be the input impedance of the following stage (connected at point 12). Ideally, this stage should be an impedance converting buffer, such as an emmiter or source follower, in order to minimise loading effects. The photodiode 10 can be operated either with zero voltage bias, resulting in the highest possible sensitivity but relatively slow response (due to the depletion layer capacitance) or with reverse bias, which yields the fastest possible response, since it minimises this capacitance. In order to avoid the possibility of applying forward bias to the photodiode (even transiently), which could damage it from exceessive power dissipation, a protection circuit has been incorporated. This consists of the diode D1 and associated resistor at the base of TR1. This part of the circuit does not have a counterpart in the general diagram shown in Figure 1, since it is specific to this particular application and it is not unique (different or additional means of protection may be incorporated at various parts of the circuit). Similarly, the coupling capacitor C2 does not have a counterpart in Figure 1. It forms effectively a high pass filter (together with the input impedance of the following circuitry), so that the dc bias voltage of the photodiode is blocked out and does not cause saturation of the following stages. It can also serve the purpose of increasing the steepness of the slope of the overall system frequency response from 6db/octave to 12 db/octave in combination with the Low Pass Filter 13, by matching the 3 db points of the two filters.

# CLAIMS

1. A control system for biasing an electronic device so that slow background fluctuations are suppressed, while excellent sensitivity is attained with high frequency modulation of the parameter constituting the useful signal. The background parameter may be the same as the signal parameter (e.g. the detection of modulated light in the presence of ambient light) but could be different (e.g. the reduction of thermal drift in a device measuring electrical signals) The system includes, in combination, an operational amplifier which compares the output voltage of the device after filtering through a low pass filter with a reference bias and a bias generating network which is driven by the operational amplifier and supplies the device with suitable biasing conditions.

2. A control system according to claim 1, wherein a signal conditioning circuit is interposed between the electronic device and the low pass filter, in order to produce a convenient output voltage.

3. A control system according to claim 1 or claim 2 wherein the bias generating network 16 acts as a high impedance dynamic load for the device 10, so that a very high value of voltage gain can be obtained, giving excellent sensitivity and improved signal to noise ratio.

4. A control system according to any of the preceding claims applied to the biasing of a photodetector as described in figure 2, wherein one or more of the following additional features have been incorporated:
a) protective means to safeguard the device against overload and
b) a coupling capacitor to avoid saturation of the following stages and to improve the filtering action at low frequencies ( increase the slope steepness of the frequency response ).

5. A control system for a photodetector, substantially as described with reference to Figures 1 and 2 of the accompanying drawings.